

# Advances in Remote Participation for Fusion Experiments

Presented by

David P. Schissel  **GENERAL ATOMICS**

Jon Farthing



Volker Schmidt



at

The 23rd Symposium on Fusion Technology  
September 20-24, 2004  
Venice, Italy

# PRESENTATION'S KEY POINTS

---

- Collaborative technology critical to the success of the FE program
  - Experimental: Fewer, larger machines in future (KSTAR, ITER)
  - Includes design, engineering and construction phase
  - Computation: Moving toward an integrated simulation
- Both the EU and US programs are implementing and testing new collaborative technologies for fusion research
  - Being used to benefit daily FE research
- Work is still needed to make RP technology suitable for routine use
  - Ease-of-use, but not neglecting security (“security with transparency”)
  - Interoperability of technologies

# ACKNOWLEDGMENT

---

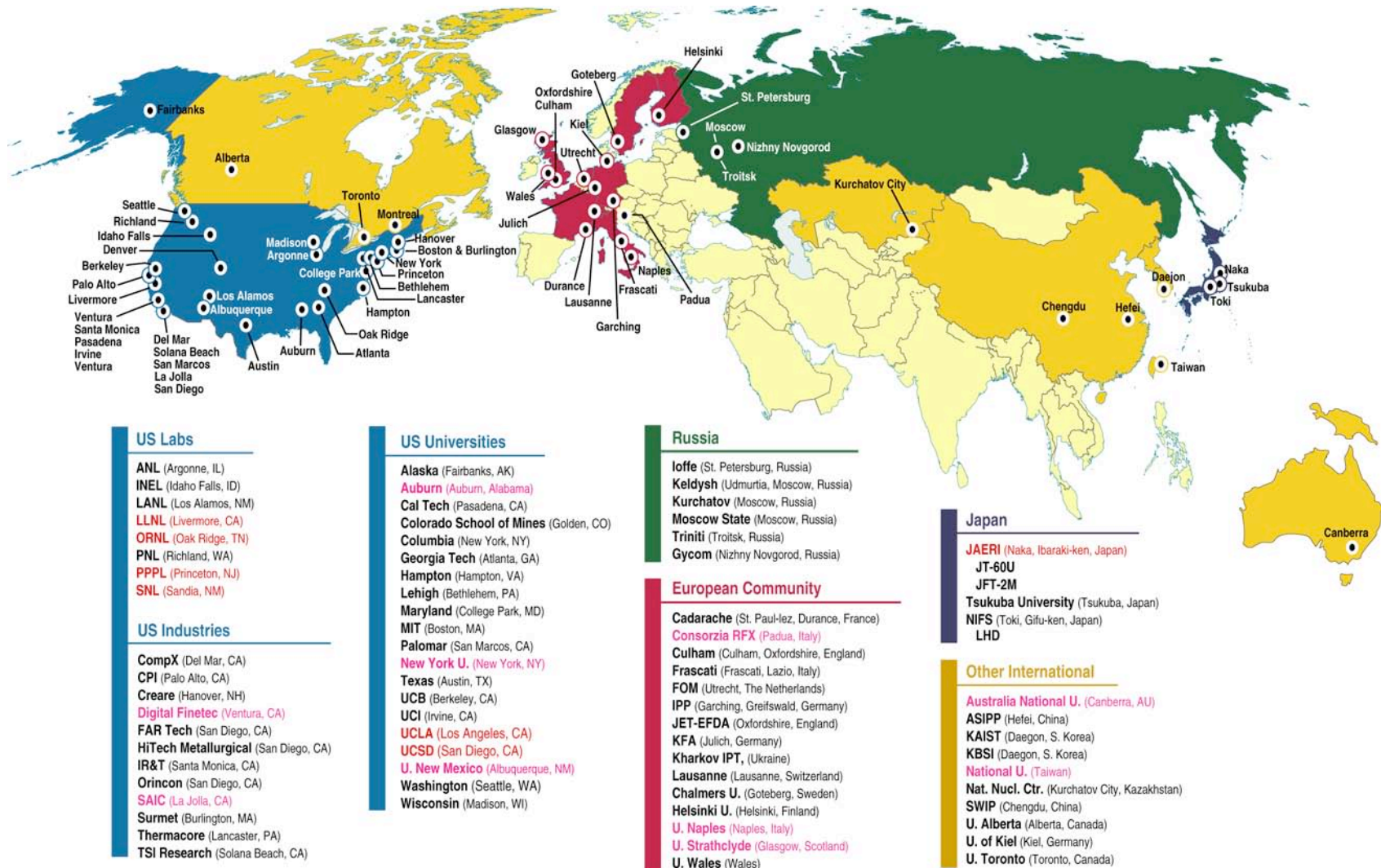
- In the United States, work is supported by the Department of Energy
  - Office of Fusion Energy Sciences
  - Office of Advanced Scientific Computing Research
  - National Fusion Collaboratory Project (<http://www.fusiongrid.org/>)
    - \* ANL, LBNL Princeton U., Utah, MIT/C-Mod, GA/DIII-D, PPPL/NSTX



- In Europe, supported by the European Commission
  - European Fusion Development Agreement (EFDA)



# EXPERIMENTAL AND THEORETICAL FUSION RESEARCH IS A WORLDWIDE EFFORT



# NATURE OF FUSION RESEARCH DRIVES REQUIREMENTS FOR COMPUTING AND NETWORKING

---

- Experiments

- Real time interactions of large, geographically extended teams
- Real time interactions between specialized small groups
- Faster between-pulse analysis translates directly to productivity
- Building an extended team of experts from small groups
- Barriers to use of powerful analysis tools can be significant

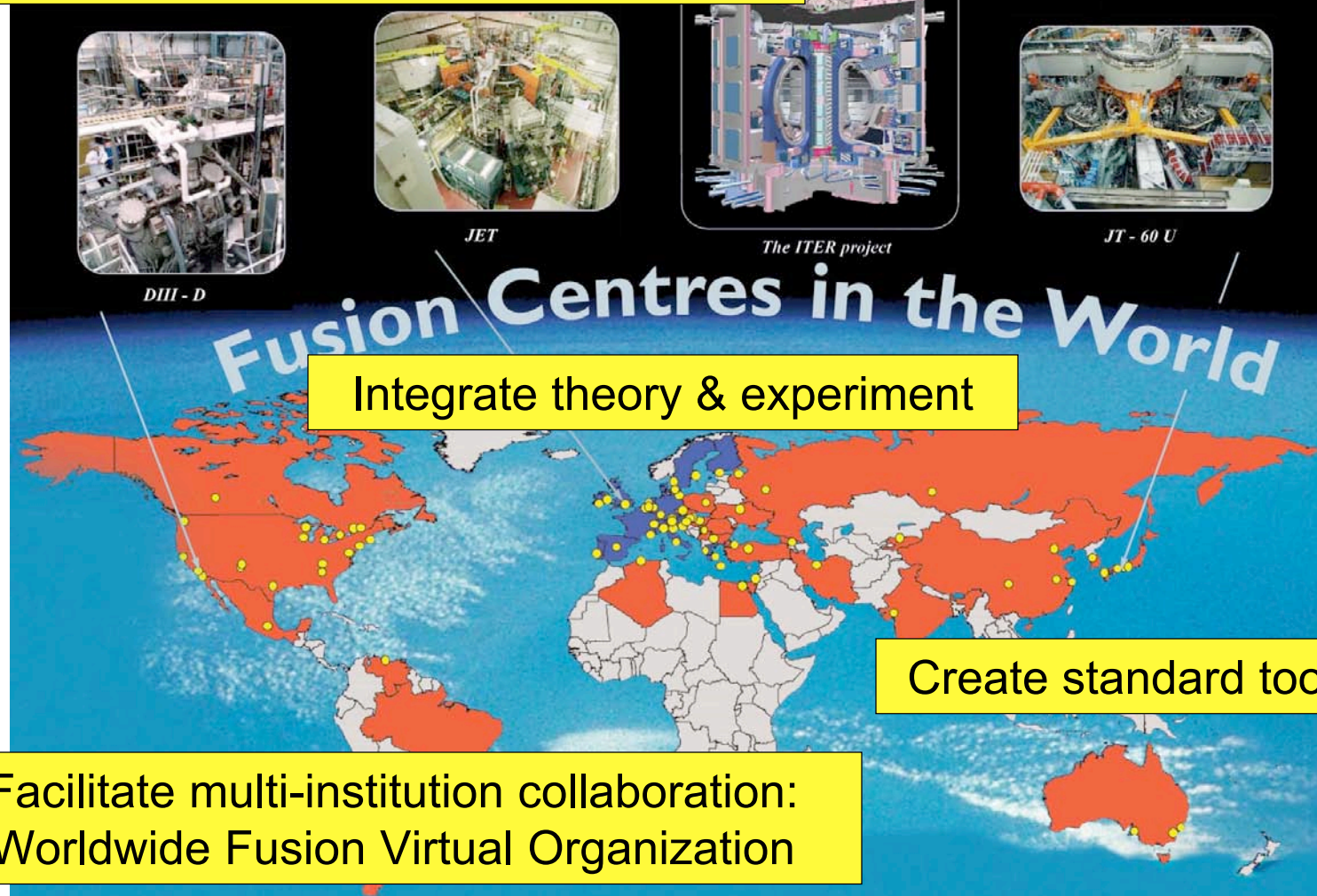
- Theory and Computation

- Simulations producing very large data sets (GB=>TB=>PB)
- Interactive visualization and analysis presents a severe challenge for computing and networking
- Increased code sharing and collaborative development
- Real time interactions of geographically extended teams



# THE GOAL OF RP TECHNOLOGY IS TO ADVANCE UNDERSTANDING & INNOVATION IN FUSION RESEARCH

More efficient use of experimental facilities



# OUR WORK FOCUSES ON FOUR AREAS

---

- Production computational Service: Grid Computing
  - Grid computing: large-scale integration of distributed computer systems
  - Power grid analogy: remote resources accessible from your laptop much the same way as electricity is delivered to your home
- Compare theory & experiment: Access to large datasets
  - Both a visualization and data handling challenge
- Fully engaged remote scientists
  - Real-time human interaction at a distance
- Tiled display wall for collocated collaboration
  - For the large groups in the tokamak control room

# NOT FOCUSING ON CONVENTIONAL GRID APPLICATIONS – CYCLE SCAVENGING & DYNAMIC CONFIGURATION

---

- Traditional computational Grids, arrays of heterogeneous servers
- Computers can join and leave
- Adaptive discovery: where problems find resources
- Workload balancing and cycle scavenging
- Bandwidth diversity where not all computers are well connected

This model is not well suited to fusion computation:  
We are aiming to move high-performance distributed  
computing out onto the wide area network



# PLACING DISTRIBUTED APPLICATIONS OUT ON THE WAN PRESENTS SIGNIFICANT CHALLENGES

---

- Crosses administrative boundaries
- Increased concerns and complexity for security including authentication and authorization
- Resources not owned by a single project or program
- Distributed control of resources by owners is essential
- Needs for end-to-end application performance & problem resolution
  - Resource monitoring, management & troubleshooting not straightforward
  - Higher latency challenges network throughput & interactivity
- People are not in one place for easy communication

# THE VISION FOR RP TECHNOLOGIES

---

- Data, Codes, Analysis Routines, Visualization Tools should be thought of as network accessible services
- Shared security infrastructure with distributed authorization and resource management
- Collaborative nature of research requires shared visualization applications and widely deployed collaboration technologies
  - Integrate geographically diverse groups
- Not focused on CPU cycle scavenging or “distributed” supercomputing (typical Grid justifications)

Optimize the most expensive resource - people's time

# VISION – RESOURCES AS SERVICES

---

- Resources are computers, codes, data analysis routines, visualization tools, experimental operations
- Access is stressed rather than portability
- Users are shielded from implementation details
- Transparency and ease-of-use are crucial elements
- Shared toolset enables collaboration between sites and across sub-disciplines
- Knowledge of relevant physics is still required of course

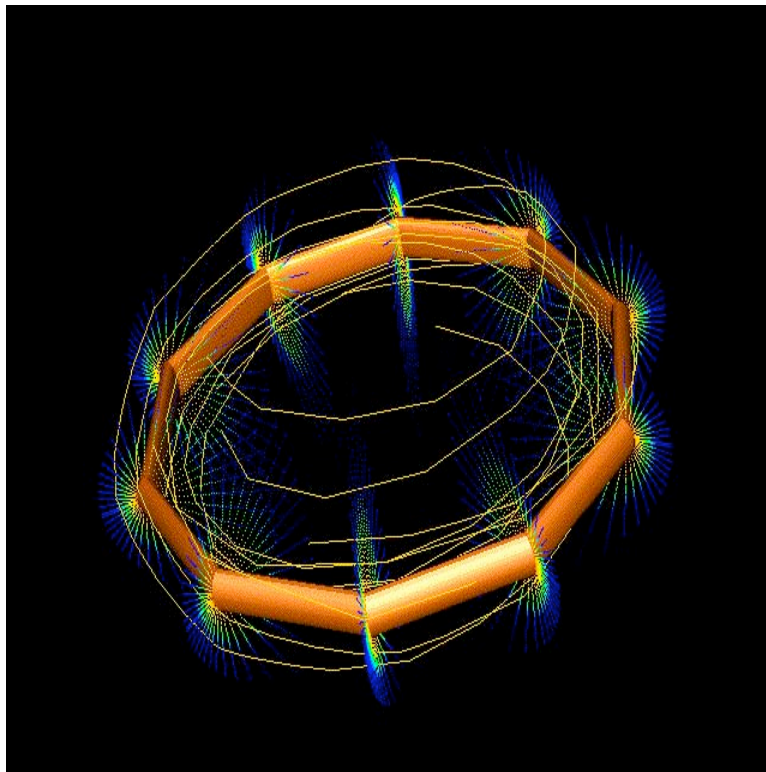
# VISION – SECURITY INFRASTRUCTURE

---

- Security with transparency
  - Ease-of-use requirement
- Strong authentication identifies users currently based on X.509 certificates from trusted Certificate Authority
  - Interoperability with international Grid Certificate Authorities
- Distributed authorization allows stakeholders to control their own resources
  - Facility owners can protect computers, data, and experiments
  - Code developers can control intellectual property
  - Fair use of shared resources can be demonstrated & controlled

# VISION – VISUALIZATION AND A/V TOOLS

- Maximum interactivity for visualization of very large datasets



- Use of extended tool sets for remote collaboration
  - Flexible collaboration environment
  - Shared applications



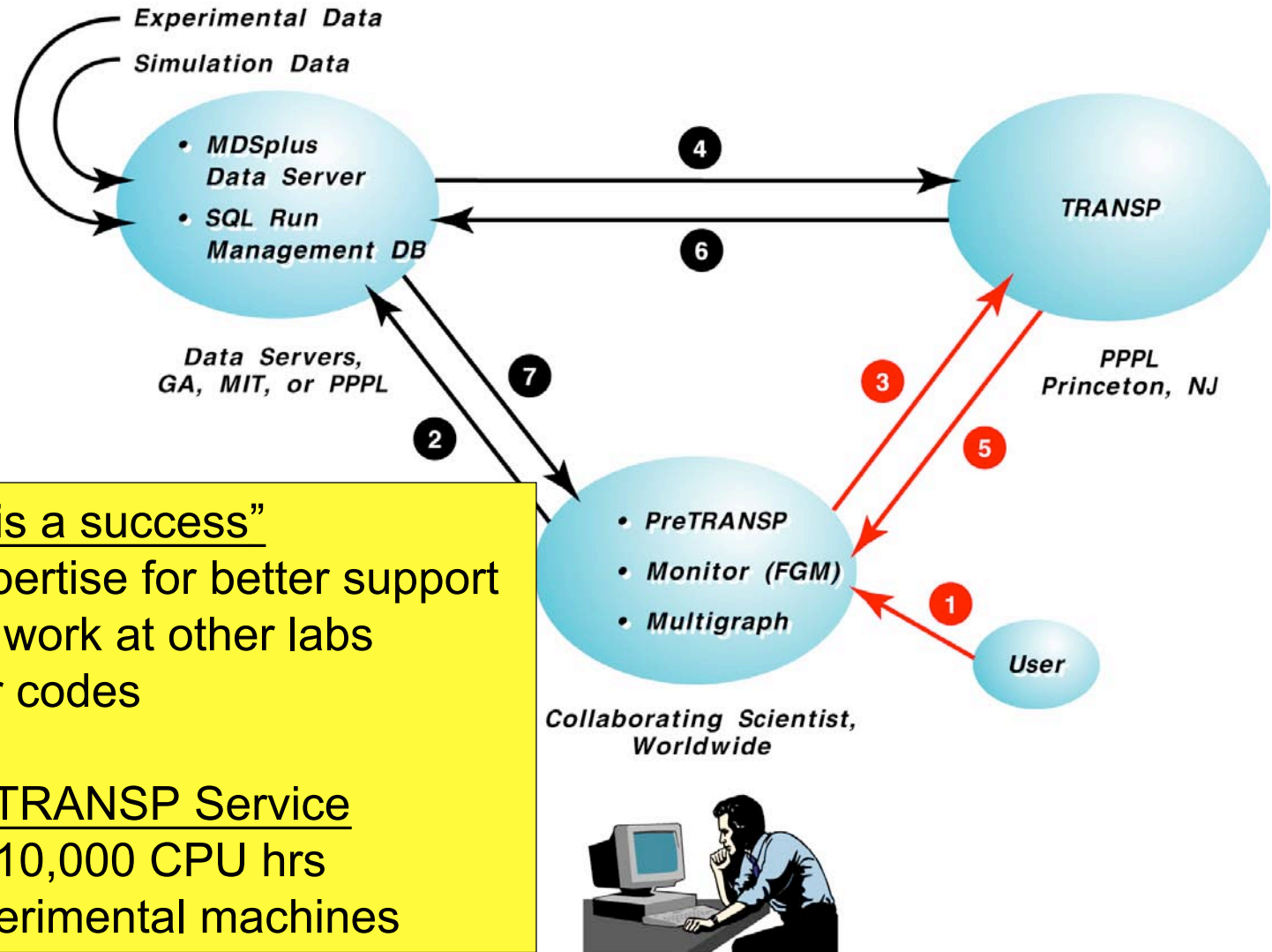
# MDSplus: SECURE ACCESS TO FUSION DATA

---

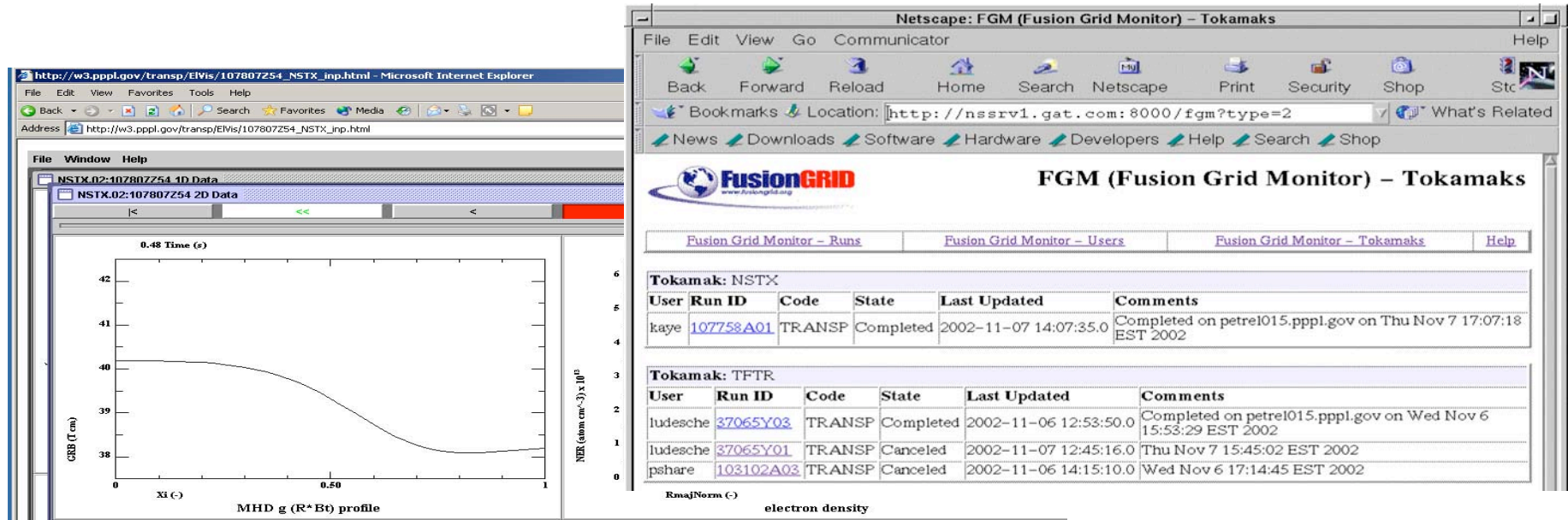


- MDSplus: remote access based on client-server model
  - In use for over 10 years (robust)
- Wide adoption worldwide
  - Unifying the data interface (e.g. Visualization)
- MDSplus data access secured with Globus GSI
  - X.509 certificates

# SUCCESSFUL GRID COMPUTING FOR FUSION SCIENCE



# FUSION GRID MONITOR: AN EFFICIENT APPLICATION MONITORING SYSTEM FOR THE GRID ENVIRONMENT



- Users track and monitor the state of applications on FusionGrid
  - Output dynamically via HTML, Built as Java Servlet (JDK2.1)
- Code maintenance notification
  - Users notified, queuing turned off, code rebuilt, queue restarted
- Results of simulation visualized during run
  - Both input and output quantities

# ADVANCED RESERVATION COMPUTATION FOR DATA ANALYSIS TO SUPPORT EXPERIMENTAL SCIENCE

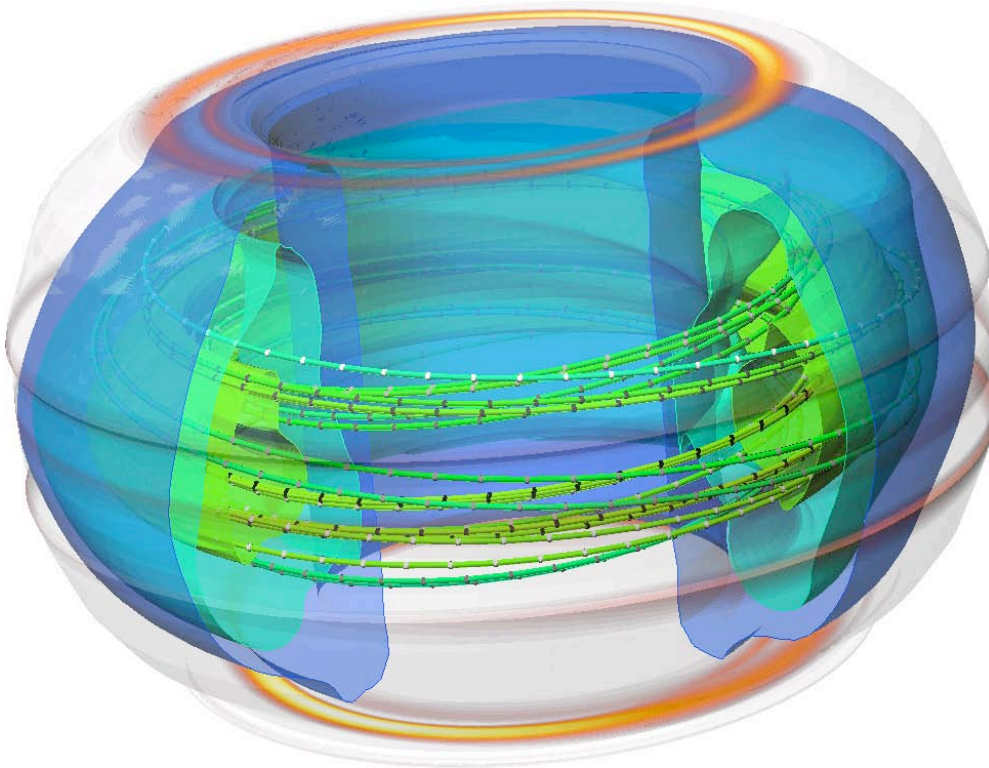
---

- Long-term vision: code runs on supercomputers between pulses
  - Data management
  - Network QoS
  - Visualization
  - CPU scheduling
  - Faster CPUs and algorithms
- End-to-end agreement being prototyped on FusionGrid
  - CPU reservation
  - Network transfer agreements based on simple prediction
- FusionGrid service TRANSP being tested between pulses
  - First such capability for fusion energy research

# VISUALIZE COMPLEX SIMULATIONS WITH EXPERIMENTAL DATA FOR BETTER UNDERSTANDING

---

- Open source, multi-platform capable for a wide user base
- To facilitate quantitative comparison of simulations & experimental results



NIMROD Simulation of a DIII-D Plasma

Raising the challenge  
of very large datasets

- MDSplus
- Storage method
- Data location
- Parallel I/O



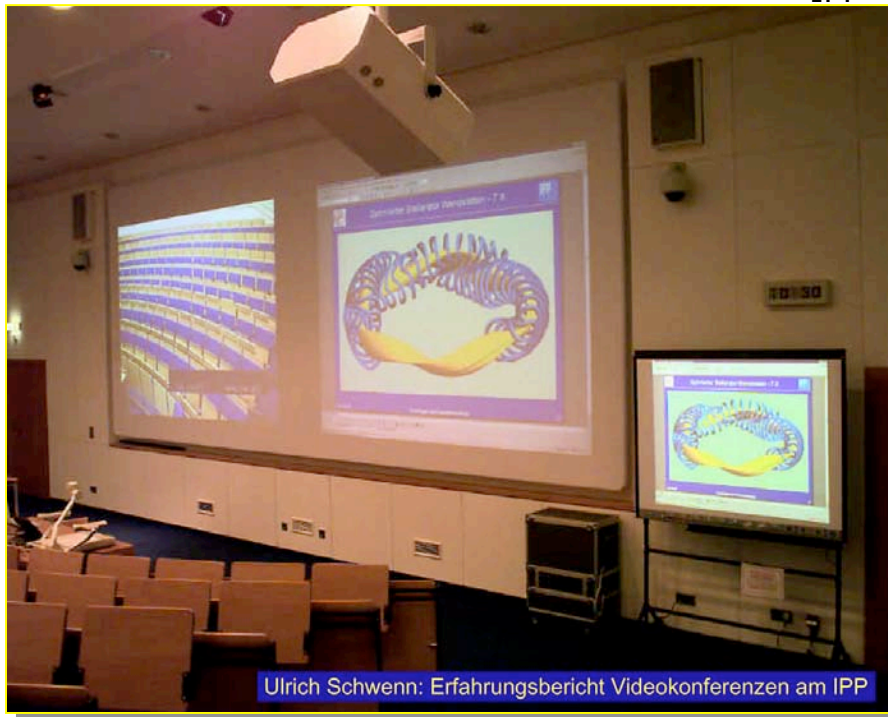
# ADVANCED COLLABORATIVE ENVIRONMENTS ENABLE INCREASED PRODUCTIVITY FOR COLLABORATIVE WORK



# VIDEO CONFERENCING OVER IP: COMMERCIAL H.323 SYSTEMS

- Numerous commercial systems available
- Point-to-point & multipoint (requires MCU)
- Hardware has built-in echo cancellation
- Video quality adjusts to available bandwidth

IPP



Ulrich Schwenn: Erfahrungsbericht Videokonferenzen am IPP

Stockholm to JET



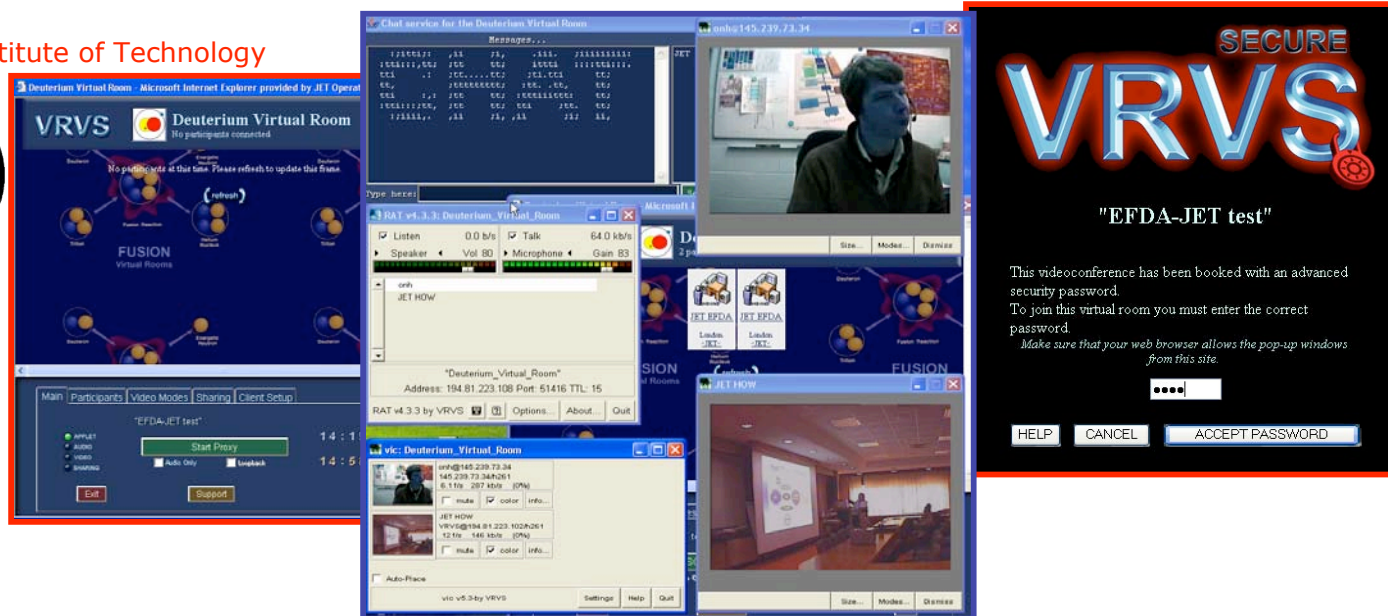
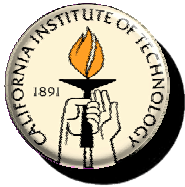


# VIDEO CONFERENCING OVER IP

## VRVS “Virtual Room Videoconferencing System”

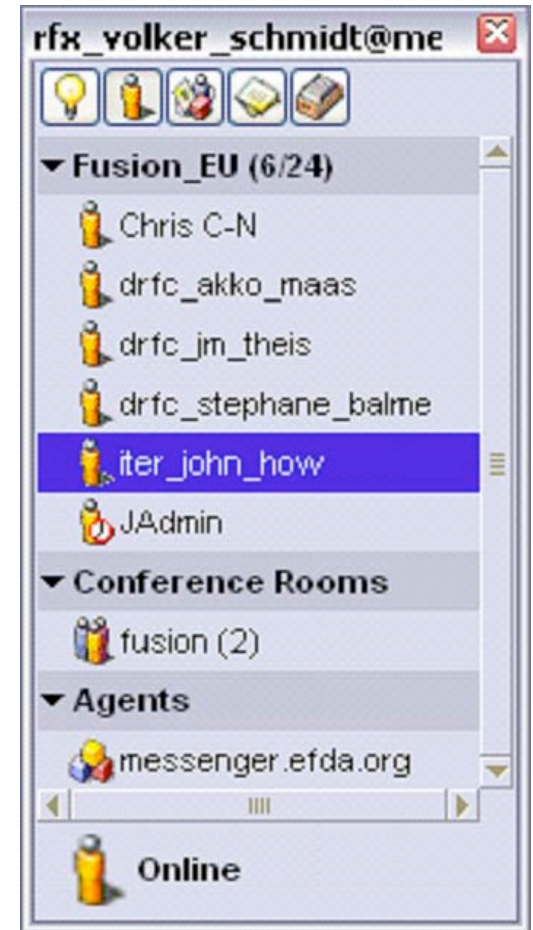
- Web-oriented, low-cost, bandwidth-efficient extensible
- Concept is of a virtual meeting room with booking system
- Grew out of HEP community but now in use elsewhere
- Proprietary infrastructure supporting a number of collaboration tools
- Uses distributed reflectors to optimize IP traffic between sites

\* California Institute of Technology



# INSTANT MESSAGING FOR ASYNCHRONOUS COMMUNICATION

- Instant Messaging (“Chat”)
  - Self-documenting tool halfway between telephone and e-mail exchanges
  - For teleconference setup & non-intrusive communication during the meeting
- Several IM tools in use in the EFDA labs
  - Originally public Yahoo Messenger, but phased out due to security concerns
  - New EFDA Garching-based secure private server running Jabber
  - VRVS and AG have their own built in chat tools



# COMPUTER DESKTOP SHARING

## VNC 'Virtual Network Computing'

---

- The European Fusion community has de facto adopted VNC
  - Allows sharing a remote desktop over the Internet
  - Viewing clients with small footprint available for most platforms
  - Open source, good support, active user community
- VNC is being routinely used for
  - one-to-one discussion meetings
  - slide presentations in tele-meetings
  - Control room screen broadcast
  - Remotely-shared engineering design work





# ACCESS GRID: REAL TIME COMPLEX COMMUNICATION



- Can be large room immersive
  - Multi-site participants
  - Application & data sharing
- Small to large nodes
  - Open source software
  - Commodity hardware
- Being used for seminars, working meetings, tokamak operations
- AG nodes are international: 150 nodes and counting
  - All UK e-Science centers have AG rooms
- Interoperability of technology is critical

# TILED DISPLAYS INSTALLED IN FUSION CONTROL ROOMS

DIII-D Tokamak Control Room



NSTX Tokamak Control Room



- Enhanced collaboration within a large control room
  - “Publish” your analysis for the group to see and discuss
- Share and collaborate between tiled displays
  - Clone of tokamak control room (discussed for ITER)

# EXPERIMENTAL SCIENCES PLACES A LARGE PREMIUM ON RAPID DATA ANALYSIS IN NEAR-REAL-TIME

---



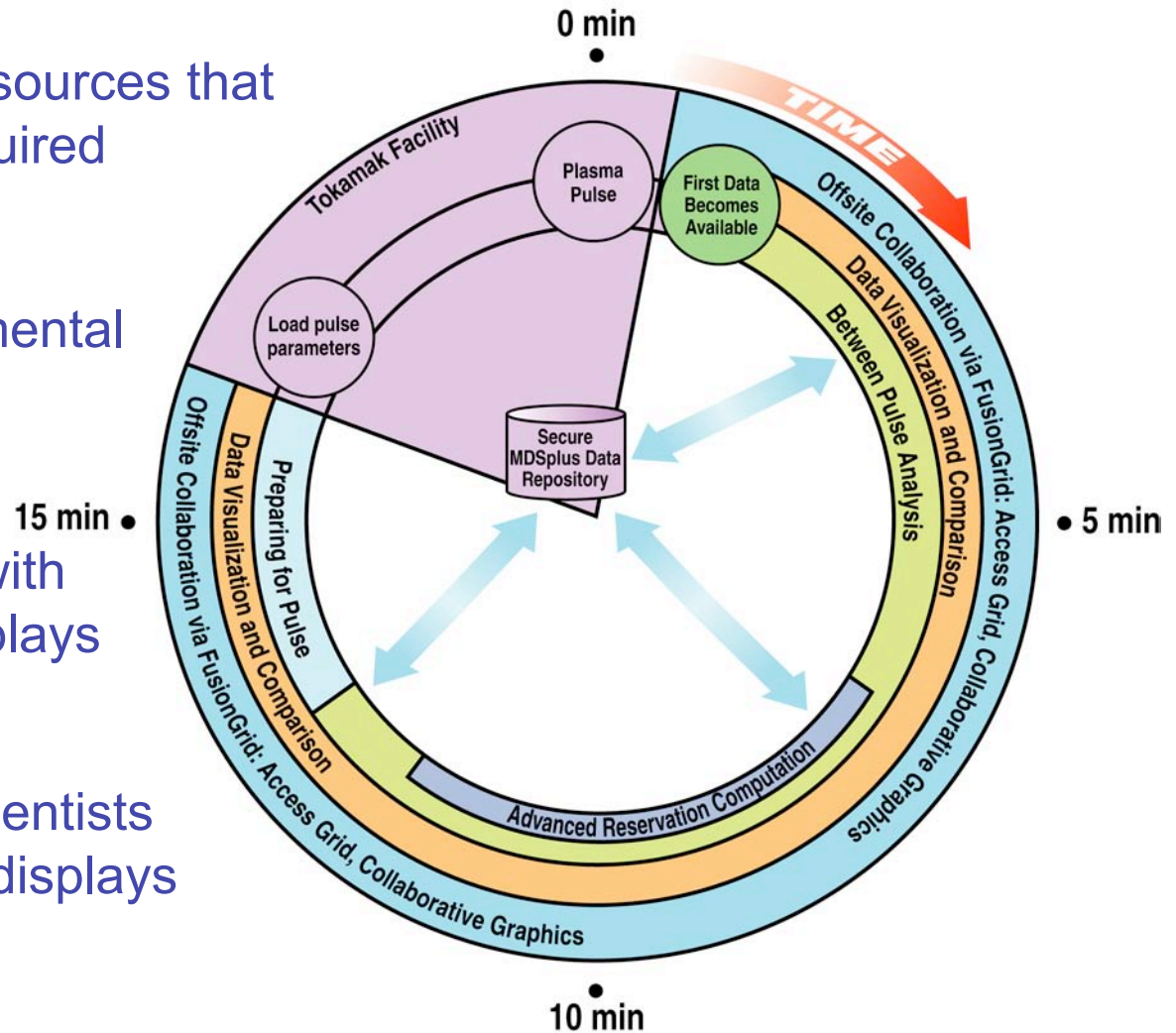
DIII-D Control Room

- Pulsed experiments
  - 10s duration plasma every 20 minutes
- 20-40 people in control room
  - More from remote locations
- 10,000 separate measurements/plasma
  - kHz to MHZ sample rates
  - Between pulse analysis
- Not batch analysis and not a needle in a haystack problem
  - Rapid “real-time” analysis of many measurements
- More informed decisions result in better experiments
  - The collaborative control room



# THE COLLABORATIVE CONTROL ROOM IS FUNDAMENTAL TO ADVANCING FUSION SCIENCE

- Secure computational resources that can be scheduled as required
- Rapidly compare experimental data to simulation results
- Share individual results with the group via shared displays
- Fully engaged remote scientists via audio, video, shared displays



# REMOTE LEADERSHIP OF THE JET TOKAMAK IN ENGLAND FROM SAN DIEGO USING RP TECHNOLOGY

January 2004, San Diego



It is becoming more common:  
Japan - US, US - Germany, & EFDA-JET



# DRFC (France) & INRS (Quebec, Canada) JOINTLY OPERATE THE LANGMUIR PROBE DIAGNOSTIC ON TORE SUPRA

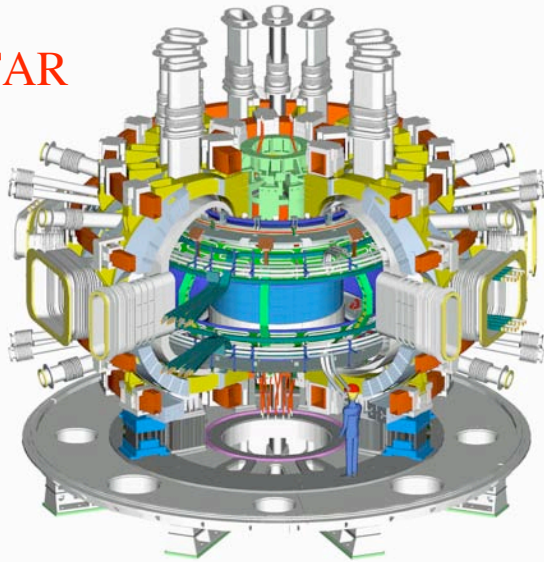
---

- Fully operational remote control room participation scenario
- Employs several RP techniques
  - Video conferencing video VRVS
  - Passive screen sharing in both directions via VNC
  - Secure remote computer login at DRFC via encrypted CITRIX
  - Data analysis tasks on INRS computers synchronized with Tora Supra pulse sequence using MDSplus events

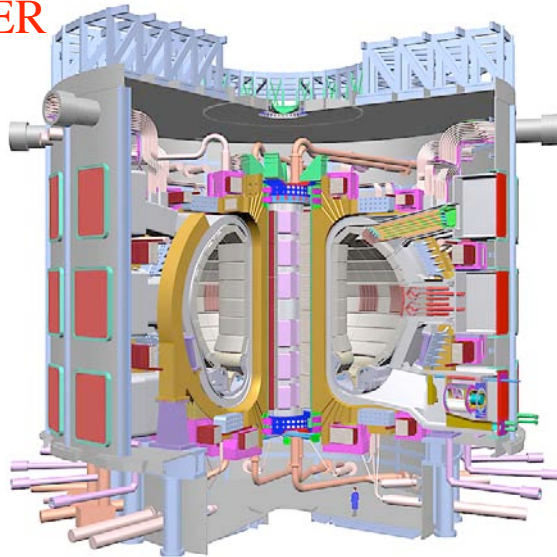


# RP TECHNOLOGIES SCALE TO THE NEXT DEVICE

KSTAR



ITER



- One physical location
  - International collaboration
- Pulsed experiment with simulations
  - ~TBs of data in 30 minutes
- Successful operation requires
  - Large simulations, shared visualization, decisions back to the control room
  - Remote Collaboration via FusionGrid
- RP technologies critical to the success of these programs
  - Including construction phase

# LESSONS LEARNED AND OUTSTANDING ISSUES

---

- Difficulties combining Grid-security and Site-security (firewalls)
  - Greatly limiting the potential expansion of the user base
- Certificate management for users and developers too difficult
  - This is often their first experience: needs to be positive
- Manipulating large multi-dimensional datasets is still a challenge
  - Need to test new approaches
- Control room presence is more than audio/video & shared apps
  - Include things one sees & hears when physically in control room
- Difficulty combining H.323, VRVS, and AG into one united meeting
  - Unlikely one solution is adopted, need easy interplay between systems
- Education, training and shared documentation
  - Users, developers, and system administrators
- Continue to learn and interact with other scientific domains
  - No need to reinvent the wheel; e.g. LHC from HEP in 2007

# CONCLUDING COMMENTS

---

- Collaborative technology critical to the success of the FE program
  - Experimental: Fewer, larger machines in future (KSTAR, ITER)
  - Computation: Moving toward an integrated simulation
- The requirements of the collaborative control room encompass in one instantiation the collaborative needs of fusion research
  - The most demanding since it is time critical and failure intolerant
- Both the EU and US programs are implementing and testing new collaborative technologies for fusion research
  - Being used to benefit daily FE research
- Technology has broad applicability beyond tokamak plasma physics
  - Design, engineering, and construction of diagnostics and machines
  - Applicable to KSTAR and ITER during construction phase